Clustering of energy balance-related behaviours, sleep, and overweight among Finnish adolescents

Nuutinen, Teija

2017-11

Nuutinen , T , Lehto , E , Ray , C , Roos , E , Villberg , J & Tynjala , J 2017 , ' Clustering of energy balance-related behaviours, sleep, and overweight among Finnish adolescents ' , International Journal of Public Health , vol. 62 , no. 8 , pp. 929-938 . https://doi.org/10.1007/s00038-017-0991-4

http://hdl.handle.net/10138/298074
https://doi.org/10.1007/s00038-017-0991-4

publishedVersion

Int J Public Health (2017) 62:929–938
DOI 10.1007/s00038-017-0991-4

ORIGINAL ARTICLE

Clustering of energy balance-related behaviours, sleep, and overweight among Finnish adolescents

Teija Nuutinen[1,2] · Elviira Lehto[1] · Carola Ray[1] · Eva Roos[1,2,3] · Jari Villberg[4] · Jorma Tynjälä[4]

Received: 22 December 2016 / Revised: 26 May 2017 / Accepted: 1 June 2017 / Published online: 7 June 2017

Abstract
Objectives To examine how clusters of energy balance-related behaviours (EBRBs), including sleep related factors, were associated with overweight among adolescents.
Methods In Finland, 4262 adolescents, aged 13–15, participated in the cross-national Health Behaviour in School-aged Children study. The adolescents completed questionnaires assessing EBRBs [sleep duration, discrepancy and quality, physical activity (PA), screen time, junk food, fruit, and vegetable intake] and height and weight. Clusters were identified with κ-means cluster analysis and their associations with overweight with logistic regression analyses.
Results Common clusters for boys and girls were labelled "Healthy lifestyle" and "High screen time, unhealthy lifestyle". In addition, the cluster "Low/moderate screen time, unhealthy lifestyle" was identified among boys, and the cluster "Poor sleep, unhealthy lifestyle" among girls. Only girls in the cluster "High screen time, unhealthy lifestyle" were at increased risk for overweight.
Conclusions Girls, whose EBRB was characterized by high screen time and low PA, but not with poor sleep, were at increased risk for overweight. Future studies should examine ways to promote PA among adolescent girls with high interest in screen-based activities.

Keywords Cluster analysis · Adolescent · Sleep · Screen time · Physical activity · Diet

✉ Elviira Lehto
elviira.lehto@folkhalsan.fi

1 Folkhälsan Research Center, Helsinki, Finland

2 Department of Public Health, University of Helsinki, Helsinki, Finland

3 Department of Food and Environmental Sciences, University of Helsinki, Helsinki, Finland

4 Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland

Introduction

Overweight and obesity are a growing public health problem worldwide among children and adolescents (Lobstein et al. 2004). The International Health Behaviour in School-aged Children (HBCS) study shows that over one-tenth of 13- to 15-year-old girls and nearly one-fourth of boys of the same age are overweight (including obese) (Inchley et al. 2016). Both overweight (Singh et al. 2008) and patterns of health behaviours established during childhood and adolescence (Craigie et al. 2011) tend to track into adulthood. Since a single health behaviour alone cannot adequately explain weight status, an approach that assumes that certain groups share similar kinds of health behaviour patterns promises to deepen our understanding of how to promote health and prevent overweight (Gubbels et al. 2013).

Among adolescents, the risk for overweight seems to increase when unhealthy behaviours co-occur (Van den Bulck and Hofman 2009). Still, not all studies have found an unambiguous co-occurrence of energy balance-related behaviours (EBRBs) or demonstrated an association between EBRBs and body mass index (BMI). In a study of the US adolescents (ages 11–21) (Boone-Heinonen et al. 2008), girls' risk for obesity was higher in almost all other constructed clusters (e.g., defined by sedentariness) than in the cluster characterized by high physical activity. Among girls, the risk was evident both cross-sectionally and longitudinally, whereas boys showed no increased risk for obesity (Boone-Heinonen et al. 2008). An HBSC study in Portugal revealed that adolescents who were physically active, but also had high screen time, had a lower BMI than the group with healthier lifestyle [high levels of physical activity (PA), low sedentary behaviour, high fruit and vegetable (FV) intake, low sweets, and soft drink intakes] (Veloso et al. 2012). Among adolescents from nine European countries, no association was found between defined clusters and weight status (Ottevaere et al. 2011), whereas in Norway, only adolescents who belonged to the "unhealthy" cluster had a significantly lower BMI (van der Sluis et al. 2010).

Most studies examining EBRBs and overweight have not included sleep-related factors in their cluster analysis (Leech et al. 2014a). Short sleep duration is, however, related not only to different adiposity indicators (Chaput et al. 2016), but also to other EBRBs, such as snacking (Nedeltcheva et al. 2009), lower levels of PA and healthy eating (Garaulet et al. 2011; Hitze et al. 2009), and high screen-based sedentary time (Nuutinen et al. 2013). In a study of Fernández-Alvira et al. (2013), schoolchildren aged 10–12 who slept less than most of their peers and were inactive showed the highest proportions of overweight. Similarly, compositional analyses by Carson et al. (2016) found that the normal-weight quartile was characterized by higher levels of moderate-to-vigorous physical activity and longer sleep. On the other hand, Pereira et al. (2015) reported that overweight was more common among schoolchildren who were more active, slept more, and had lower diet quality and higher screen time, as defined in a latent class analysis. Similar to short sleep duration, also poor sleep quality, such as insomnia and sleep problems, has been found to associate with overweight (Jarrin et al. 2013) as well as with high screen-based sedentary time (Johnson et al. 2004; Yen et al. 2008). Therefore, it would be important to include different sleep-related factors when examining EBRBs and their associations with overweight among adolescents. Since EBRB cluster membership has been found to vary according to parental socioeconomic status in many (Boone-Heinonen et al. 2008; Fernández-Alvira et al. 2013; Leech et al. 2014b; Ottevaere et al. 2011), but not in all (Sabbe et al. 2008) studies, socioeconomic status should be taken into account, as well.

Aims

The first aim of the present study is to investigate the presence of clusters according to EBRBs, including sleep duration, the discrepancy of sleep duration between school and weekend nights, sleep quality, PA, junk food intake, fruit and vegetable intake, and screen time (TV viewing, computer use, and playing games on the computer) among 13- to 15-year-old Finnish adolescents. The second aim is to examine whether the identified clusters of EBRBs associate with overweight (BMI >25 kg/m^2).

Methods

Data

The data came from the Finnish subset of the cross-national Health Behaviour in School-aged Children (HBSC) study in 2010. The HBSC study is based on a school survey whose questions assessed wide range of health behaviours and health indicators. Researchers collect the data and administer the survey through schools every fourth year. The HBSC study comprises nationally representative samples of 11-, 13-, and 15-year-old adolescents. The minimum recommended sample size, based on power calculations, is 1536 adolescents in each of the three age groups. Sampling is described in more detail in the study protocol (Griebler et al. 2010). In Finland, schools are selected by cluster sampling from school registers after taking into account the size of schools and regions. One class is then selected randomly from each school. Adolescents complete the internationally standardized questionnaire developed by the international research network in the classroom. The validity and reliability of the measures have been examined in different countries (Griebler et al. 2010; Tynjälä 1999). In this study, we use cross-sectional data on Finnish 13- to 15-year-old adolescents ($n = 2152$ and 2110, response rates 93 and 96%).

The adolescents' participation was voluntary and based on informed consent. Ethics approval came from the National Board of Education and the Trade Union of Education. In addition, each school's headmaster independently decided whether to participate in the study.

Measures

Screen time

TV viewing was measured with the question: "How many hours a day do you usually watch TV, DVDs, or videos on schooldays/weekends?" The questionnaire assessed computer use with two questions: "How many hours a day do you usually use a computer for chatting, surfing the internet, emailing, or doing your homework on schooldays/weekends?" and "How many hours a day do you usually play computer or console games (Playstation, Xbox) on schooldays/weekends?" In this study, the former is called computer use, and the latter, playing on the computer. Response categories for each variable were "not at all", "half an hour", "1 h", "2 h", "3 h", "4 h", "5 h", "6 h", and "7 h or more", coded as 0, 0.5, 1…to 7. Separate continuous variables in the cluster analysis included TV viewing, computer use, and playing on the computer.

Sleep duration

Bedtimes were elicited as follows: "When do you usually go to bed if the next morning is a school day/weekend?" Answering alternatives for bedtimes on school nights ranged in half-hour intervals from "at latest 9 p.m." to "2 a.m. or later" and on weekend nights from "at latest 9 p.m." to "4 a.m. or later". We assessed wake-up times with the question: "When do you usually wake up on school mornings/weekend mornings?" Response categories for wake-up times on school mornings ranged in half-hour intervals from "5 a.m. at the latest" to "8 a.m. or later" and on weekend mornings from "7 a.m. at the latest" to "2 p.m. or later". We then calculated a continuous sleep duration variable with the following formula: 24 − bedtime + wake-up time. In the cluster analyses, we used only sleep duration on school nights, due to its representativeness of the typical sleep duration with a more regular bed and wake-up routine as well as its stronger association with weight status (Altenburg et al. 2013).

Discrepancy of sleep duration

We calculated a continuous variable representing the discrepancy of sleep duration as sleep duration on weekend night—sleep duration on school nights.

Sleep quality

Sleep quality includes difficulty falling asleep, nocturnal awakenings, and sleep onset latency. Difficulty falling asleep and nocturnal awakenings were assessed with the question: "How often have you had the following symptoms during the past 6 months?" Answer alternatives ranged from "1 = almost daily" to "5 = less than once a month or never". The question assessing sleep onset latency was "How fast do you usually fall asleep?" and the answer alternatives ranged from "1 = in 10 min or less" to "5 = it usually takes over 40 min to fall asleep". Sleep onset latency was rotated (the highest score indicating a lower latency) before calculating the continuous sleep quality sum-variable. Cronbach's alpha for girls was 0.71, and for boys, 0.66.

Junk food intake

Junk food intake is a continuous sum variable of the five questions: "How often do you eat hamburgers or hot dogs/potato chips/pizza/candies or chocolate?" and "How often do you drink coke or other soft drinks that contain sugar?" Answer alternatives ranged from "1 = never" to "7 = every day, more than once". Cronbach's alpha for girls was 0.64, and for boys 0.74.

Fruit and vegetable intake

FV intake is a continuous sum-variable of the two questions: "How often do you eat vegetables/fruits?" Answer alternatives ranged from "1 = never" to "7 = more than once every day". Cronbach's alpha for girls was 0.70, and for boys 0.73.

Physical activity

Physical activity was assessed with the question "How many hours a week outside of school hours do you usually exercise, such that you get out of breath and sweat?" Answer alternatives ranged from "1 = not at all" to "6 = seven or more hours". The variable was categorized as follows: 1 = 0–1 h per week, 2 = 2–3 h per week, and 3 = 4–7 h per week.

Overweight

The participants were asked to indicate their weight in kilograms and their height in centimeters. Their BMI was calculated by dividing their weight in kilograms by the square of their height in meters (kg/m^2). We then, using cut-off points adapted from Cole et al. (2000), dichotomized BMI as normal weight and overweight (including obese) (BMI over 25 kg/m^2).

Covariates

Adolescents' age and educational aspiration served as covariates in the logistic regression analysis. Educational aspiration, which has been reported to reflect on parental educational status among adolescents (Dubow et al. 2009), was measured with the question: "What do you think you will do when you finish compulsory basic education?" The answer alternatives were "1 = Try to enter general upper secondary education", "2 = Try to enter vocational upper secondary education or other vocational training", "3 = Try to find an apprenticeship", "4 = Take the double examination (e.g., general upper secondary education and vocational upper secondary education)", "5 = Find a job", "6 = Be unemployed", and "7 = Don't know". Educational aspiration was dichotomized as follows: 1 = Try to enter general upper secondary education and 0 = the remaining categories.

Statistical analyses

We analysed the data with the Statistical Package for the Social Sciences version 20 for Windows (SPSS) and calculated the means, standard deviations and proportions to describe the key variables. Gender differences in EBRBs and BMI were examined with the independent sample *t* test, the Mann–Whitney *u* test, or the χ^2 test depending on the distribution and the scale of the variable.

Co-occurring patterns of EBRBs were identified with a κ-means cluster analysis. The analyses included 3865 adolescents [mean age 14.7 (SD 1.0), $n = 2051$, girls 53%; $n = 1814$, boys 47%], and were performed separately according to gender due to significant differences in EBRBs (Table 1). All variables were transformed into standardized *Z*-scores to standardize the scaling (mean 0, standard deviation 1) across the variables prior to clustering. Taking a random subsample of 50% of the total sample and repeating the cluster analysis with this internal subsample confirmed the stability of the constructed cluster solution. Comparing the cluster memberships of the subsample to those of the total sample and calculating a kappa degree of agreement confirmed the reliability of the cluster memberships. In all, we tested two-, three-, and four-cluster solutions, from which the three-cluster solution proved the most meaningful and reliable. ANOVA and post hoc tests with Bonferroni corrections served to examine the differences in EBRBs between the clusters.

Logistic regression analysis served to examine the associations between the clusters of EBRBs and overweight. All regression models were performed separately for girls and boys and were adjusted for age and educational aspiration. The level of statistical significance was <0.05.

Results

Descriptive statistics of EBRBs and BMI appear in Table 1. Gender differences were evident: boys slept more, enjoyed higher sleep quality, and had a shorter discrepancy of sleep duration between school and weekend nights than did girls. Although boys were more physically active, they also played more computer games. Girls, compared to boys, watched more TV and used the computer for purposes other than playing. Girls also more often ate fruits and vegetables and less often junk food than boys did. Girls reported upper secondary school as their educational

Table 1 Descriptive statistics of EBRBs, BMI, age, and educational aspiration among 13- to 15-year-old in the HBSC Study (Health Behaviour in School-aged Children, Finland 2010)

	Boys (n = 1947–2053)	Girls (n = 2067–2209)	*P* value
TV viewing, average (h:mm/day)	2:35 (1:34)	2:45 (1:30)	0.001
Playing on the computer, average (h:mm/day)	2:02 (1:41)	0:35 (1:03)	<0.001
Computer use, average (h:mm/day)	2:07 (1:37)	2:16 (1:32)	0.002
Sleep duration on school nights (h:mm/night)	8:20 (0:57)	8:07 (0:57)	<0.001
Discrepancy of sleep duration (h:mm/day)	1:36 (1:31)	1:55 (2:25)	<0.001
Sleep quality [3 (poor)–15 (good)]	12.1 (2.5)	11.2 (2.9)	<0.001
Junk food intake [5 (never)–35 (daily)]	14.2 (3.2)	13.0 (2.7)	<0.001
Fruit and vegetable intake [2 (never)–14 (daily)]	8.3 (2.5)	9.3 (2.5)	<0.001
Physical activity h/week, %			<0.001
0–1 h/week	38	45	
2–3 h/week	27	29	
4–7 h or more/week	35	27	
Body mass index, BMI %			<0.001
Normal weight	81	87	
Overweight (including obese)	19	13	
Age category %			ns
13 years old	51	50	
15 years old	49	50	
Educational aspiration %			<0.001
Upper secondary school	48	60	
Other than upper secondary school	52	40	

Gender differences in EBRBs, BMI, age, and educational aspiration tested with independent sample *t* test, Mann–Whitney test, and χ^2 test depending on the scale and distribution of the variable

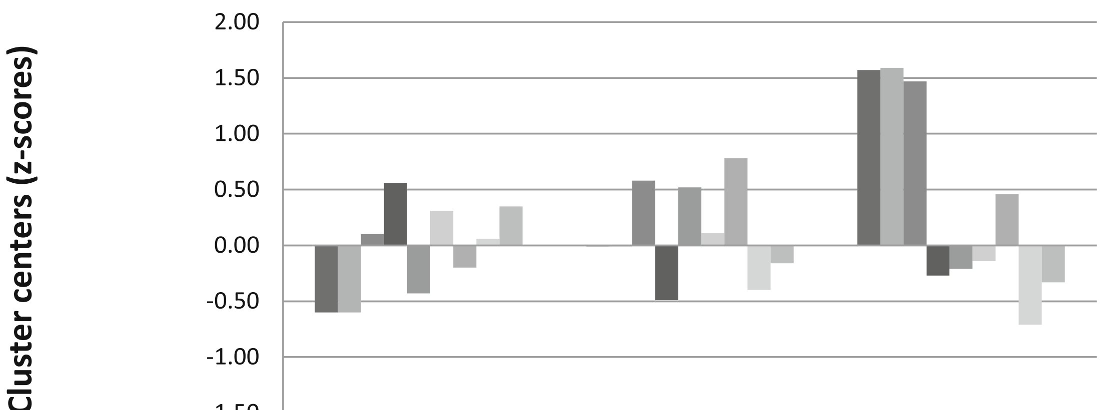
BMI body mass index, *EBRBs* energy balance-related behaviours, *h* hours, *m* minutes, *ns* non-significant aspiration more often than did boys. Overweight was more prevalent among boys (19%) than girls (13%).

Description of the clusters

The κ-means cluster analysis resulted in three reliable and meaningful clusters of EBRBs for boys and girls. We labelled the clusters according to the most prominent behaviours in each. The cluster labelled "Healthy lifestyle" was observed among both boys ($n = 996$, 55%) and girls ($n = 1112$, 54%). The second cluster "High screen time, unhealthy lifestyle" was also identified among boys ($n = 308$, 17%) and girls ($n = 505$, 25%). The third cluster was labelled among boys as "Low/moderate screen time, unhealthy lifestyle" ($n = 510$, 28%) and among girls as "Poor sleep, unhealthy lifestyle" ($n = 434$, 21%). Good agreement was found (Cohen's Kappa among boys: $\kappa = 0.906$, $P < 0.001$; girls: $\kappa = 0.867$, $P < 0.001$).

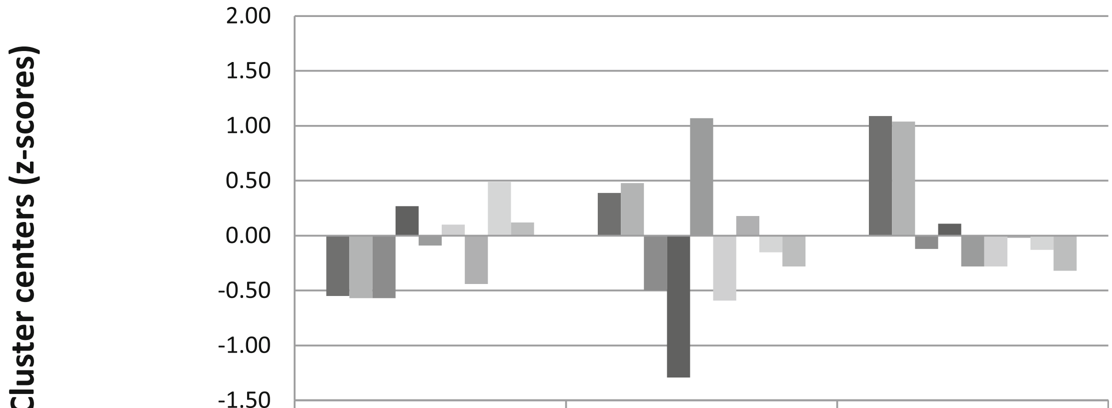
Figures 1 and 2 show final cluster centres (z-scores) for each cluster for boys and girls. The cluster "Healthy lifestyle" shows high-to-moderate z-scores (above 0) on sleep duration, sleep quality, PA, and FV intake, and low z-scores on TV viewing, computer use, playing on the computer (only girls), junk food intake, and sleep discrepancy. The cluster "High screen time, unhealthy lifestyle" shows high z-scores on TV viewing, computer use, playing on the computer, and junk food intake, and low z-scores on sleep duration, sleep discrepancy, sleep quality, PA, and FV intake. Among boys, the cluster "Low/moderate screen time, unhealthy lifestyle" shows low z-scores on sleep duration, PA, FV intake, TV viewing, and computer use, and high z-scores on junk food intake, playing on the computer, and sleep discrepancy. Among girls, the cluster "Poor sleep, unhealthy lifestyle" shows high/moderate z-scores on TV viewing, computer use, junk food intake, and sleep discrepancy. Sleep duration, sleep quality, PA, FV intake, and playing on the computer all showed low scores.

Mean values (not standardized) of the EBRBs and statistically significant differences between the clusters appear in Table 2. Statistically significant differences occurred in most EBRBs among both genders. Boys and girls in the cluster "Healthy lifestyle", compared to other clusters, more often reported upper secondary school as an educational aspiration. The proportion of younger adolescents was higher in the cluster "Healthy lifestyle" (Table 2).



	Healthy lifestyle	Low/moderate screen time, unhealthy lifestyle	High screen time, unhealthy lifetime
TV viewing	-0.60	-0.01	1.57
Computer use	-0.60	-0.01	1.59
Playing on the computer	0.10	0.58	1.47
Sleep duration	0.56	-0.49	-0.27
Discrepancy of sleep duration	-0.43	0.52	-0.21
Sleep quality	0.31	0.11	-0.14
Junk food intake	-0.20	0.78	0.46
Fruit and vegetable intake	0.06	-0.40	-0.71
Physical activity	0.35	-0.16	-0.33

Fig. 1 Final cluster centres (standardized z values) of the energy balance-related behaviours, k-means cluster analysis for 13- to 15-year-old boys ($n = 1814$) in the HBSC study (Health Behaviour in School-aged Children, Finland 2010)



	Healthy lifestyle	Poor Sleep, unhealthy lifestyle	High screen time, unhealthy lifetime
TV viewing	-0.55	0.39	1.09
Computer use	-0.57	0.48	1.04
Playing on the computer	-0.57	-0.50	-0.12
Sleep duration	0.27	-1.29	0.11
Discrepancy of sleep duration	-0.09	1.07	-0.28
Sleep quality	0.10	-0.59	-0.28
Junk food intake	-0.44	0.18	-0.02
Fruit and vegetable intake	0.49	-0.15	-0.13
Physical activity	0.12	-0.28	-0.32

Fig. 2 Final cluster centres (standardized *z* values) of the energy balance-related behaviours, k-means cluster analysis for 13- to 15-year-old girls ($n = 2051$) in the HBSC Study (Health Behaviour in School-aged Children, Finland 2010)

Associations between clusters of EBRBs and overweight

Table 3 shows odds ratios for overweight by clusters. The risk for overweight was higher among girls in the cluster "High screen time, unhealthy lifestyle" than among those in the "Healthy lifestyle" cluster. There was no elevated risk for overweight among girls in the cluster "Poor sleep, unhealthy lifestyle" compared to the cluster "Healthy lifestyle". Among boys, the risk for overweight did not differ in those belonging to the "High screen time, unhealthy lifestyle" or "Low/moderate screen time, unhealthy lifestyle" clusters compared to those in the "Healthy lifestyle" cluster.

Discussion

We found three reliable and meaningful clusters of EBRBs among Finnish 13- to 15-year-old boys and girls. In our study, the cluster solutions differed somewhat according to gender, as has been reported in other studies, as well (Leech et al. 2014a). Common clusters for both genders were labelled "Healthy lifestyle" and "High screen time, unhealthy lifestyle". In addition, the cluster "Low/moderate screen time, unhealthy lifestyle" was identified among boys. Among girls, the third cluster was labelled "Poor sleep, unhealthy lifestyle". Over half of both girls and boys were in the cluster "Healthy lifestyle", characterized by high PA, healthy diet, low screen time, as well as with recommended levels of sleep duration and high sleep quality. The "Healthy lifestyle" cluster was also characterized by a higher proportion of younger adolescents, which the previous studies have also reported (Cuenca-García et al. 2013).

We found a greater risk for overweight only among girls in the "High screen time, unhealthy lifestyle" cluster when compared to the "Healthy lifestyle" cluster. Similar to our results, a study of 11-year-old children (te Velde et al. 2007) found that girls in the clusters characterized by high TV viewing and computer use were at higher risk for overweight compared to girls in the healthy behaviour cluster characterized by low TV viewing, low computer use, and high PA level. Although overweight was more prevalent among boys in our study, we found no significant associations between clusters of EBRBs and overweight among boys. In agreement with this result, a US study demonstrated the association between EBRBs and obesity mainly only among

Table 2 Mean values and percentages of EBRBs, age, and educational aspiration by clusters among 13 to 15 years old in the HBSC Study (Health Behaviour in School-aged Children, Finland 2010) ($n = 3865$)

	Boys ($n = 1814$)			Girls ($n = 2051$)		
	Healthy lifestyle ($n = 996$) Mean (SD)	Low/moderate screen time, unhealthy lifestyle ($n = 510$) Mean (SD)	High screen time, unhealthy lifestyle ($n = 308$) Mean (SD)	Healthy lifestyle ($n = 1112$) Mean (SD)	Poor sleep, unhealthy lifestyle ($n = 434$) Mean (SD)	High screen time, unhealthy lifestyle ($n = 505$) Mean (SD)
TV viewing (h:mm/day)	1:45 (0:56)[b,c]	2:39 (1:03)[a,c]	5:05 (1:05)[a,b]	1:50 (0:49)[b,c]	3:17 (1:20)[a,c]	4:21 (1:07)[a,b]
Computer use (h:mm/day)	1:14 (0:51)[b,c]	2:11 (1:04)[a,c]	4:42 (1:21)[a,b]	1:17 (0:42)[b,c]	2:57 (1:24)[a,c]	3:50 (1:19)[a,b]
Playing on the computer (h:mm/day)	1:26 (1:10)[b,c]	2:11 (1:35)[a,c]	3:34 (2:02)[a,b]	0:23 (0:37)[c]	0:30 (0:58)[c]	1:00 (1:33)[a,b]
Sleep duration (h:mm/night)	8:45 (0:40)[b,c]	7:43 (0:52)[a,c]	7:56 (1:02)[a,b]	8:27 (0:42)[b,c]	6:56 (0:49)[a,c]	8:18 (0:43)[a,b]
Discrepancy of sleep duration (h:mm)	1:08 (0:14)[b,c]	2:31 (1:20)[a,c]	1:27 (1:35)[a,b]	1:38 (1:12)[b,c]	3:20 (1:09)[a,c]	1:21 (1:14)[a,b]
Sleep quality [3 (poor)–15 (good)]	12.5 (2.2)[b,c]	11.9 (2.6)[a,c]	11.3 (2.9)[a,b]	11.9 (2.6)[b,c]	10.0 (3.1)[a,c]	10.9 (2.9)[a,b]
Junk food intake [5 (never)–35 (daily)]	13.0 (2.2)[b,c]	15.9 (3.4)[a,c]	15.0 (3.1)[a,b]	12.2 (2.2)[b,c]	14.1 (3.1)[a,c]	13.5 (2.8)[a,b]
Fruit and vegetable intake [2 (never)–14 (daily)]	9.0 (2.4)[b,c]	7.8 (2.2)[a,c]	7.0 (2.2)[a,b]	10.1 (2.3)[b,c]	8.5 (2.3)[a]	8.5 (2.4)[a]
Physical activity % (h/week)	[b,c]	[a]	[a]	[b,c]	[a]	[a]
0–1	28	49	55	37	52	55
2–3	29	24	24	30	28	29
4–7	43	27	21	33	20	17
Age category %	[b,c]	[a]	[a]	[b,c]	[a]	[a]
13 years old	63	23	14	56	16	28
15 years old	47	33	20	51	26	24
Educational aspiration %	[b,c]	[a]	[a]	[b,c]	[a]	[a]
Upper secondary school	55	44	39	69	51	53
Other than upper secondary school	45	56	61	32	49	47

Significance test with one-way ANOVA (analysis of variance), multiple comparisons Bonferroni correction, and χ^2 test (age category and educational aspiration), significance level = $P \leq 0.001$

EBRBs energy balance-related behaviours, *h* hours, *m* minutes, *SD* standard deviation

[a] Significant difference compared to Healthy lifestyle

[b] Significant difference compared to Low/moderate screen time, unhealthy lifestyle (boys)/poor sleep, unhealthy lifestyle (girls)

[c] Significant difference compared to High screen time, unhealthy lifestyle (boys and girls)

Table 3 Associations between clusters of EBRBs and overweight (including obese) among 13 to 15 years old in the HBSC Study (Health Behaviour in School-aged Children, Finland 2010) (logistic regression analysis)

	Overweight OR (95% CI)
Boys ($n = 1814$)	
Healthy lifestyle ($n = 996$)	1.00 (referent)
High screen time, unhealthy lifestyle ($n = 308$)	1.34 (0.97–1.86)
Low/moderate screen time, unhealthy lifestyle ($n = 510$)	1.08 (0.81–1.43)
Girls ($n = 2051$)	
Healthy lifestyle ($n = 1112$)	1.00 (referent)
High screen time, unhealthy lifestyle ($n = 505$)	**1.42 (1.05–1.94)**
Poor sleep, unhealthy lifestyle ($n = 434$)	1.05 (0.73–1.51)

We adjusted logistic regression analyses for age and educational aspiration

Bold value indicates significance level ($P < 0.05$)

CI confidence interval, *EBRBs* energy balance-related behaviours, *OR* odds ratio

adolescent girls, whereas among boys, only the cluster characterized by high junk food and smoking inversely associated with obesity (Boone-Heinonen et al. 2008). Without further research, the reason for the lack of associations between clusters of EBRBs and overweight among boys can only be hypothesized. One explanation can be the boys' greater need for energy during the fast growth process in adolescence, which would mean that the effects of high screen-based sedentary time, low levels of PA, and unhealthy eating would potentially not be seen until early adulthood. Although BMI scores were adjusted for gender and age, it can be that physically active boys' tendency to gain more muscle mass compared to girls can still attenuate the association between EBRBs and risk for overweight.

In general, screen time among boys and girls in our study was higher than recommended (Strasburger et al. 2013), and similar to other studies (Altenburg et al. 2013; Boone-Heinonen et al. 2008), boys spent more time in front of the screen than girls. Still, high screen time alone does not necessarily associate with overweight, since the combination of different EBRBs is what matters. A Portuguese study, which included boys and girls together in the analyses, stated that the smallest BMI occurred in a cluster characterized by both higher screen time and high PA, compared to the group with healthier behaviours such as high PA, low sedentary behaviour, high FV intake, low sweets, and soft drink intakes (Veloso et al. 2012). In the study by te Velde et al. (2007), boys' risk for overweight was, compared to the healthy behaviour cluster, higher in the cluster characterized by high computer use but not in the cluster characterized by high TV viewing. The authors link the discrepancy in the associations with overweight between the clusters defined by two different types of high screen time to the fact that boys in the high TV viewing cluster also had the highest PA level.

It is noteworthy that sleep duration and the discrepancy of sleep duration were the key variables differentiating the clusters between girls and boys. Girls tended to fall in the cluster "Poor sleep, unhealthy lifestyle", characterized by short sleep duration (about 7 h) on school nights, which does not meet the recommendation of 8–10 h sleep per night for adolescents (Hirshkowitz et al. 2015). Girls in this cluster also had a high discrepancy of sleep duration between school and weekend nights, which probably means that girls recover during the weekend the sleep loss they incur during the school week. Such irregularity (social jet lag) in sleep patterns associates with obesity and metabolic dysfunction in middle age, whereas among adolescents, irregular sleep schedules associate with impaired cognitive abilities, behavioural problems, and fatigue (Parsons et al. 2015; Touitou 2013).

In our study, we observed no increased risk for overweight in the group characterized by poor sleep, which is understandable, since health risks could be more prone to emerge over the long run (Parsons et al. 2015). On the other hand, a study of school-aged children reported the highest proportions of overweight among girls and boys who were inactive and slept the least, whereas the smallest proportions of overweight occurred among girls who were inactive and slept the most (Fernández-Alvira et al. 2013). Still, the importance of sufficient sleep and its co-occurrence with other EBRBs was also demonstrated in our study: those adolescents who slept the most (9 h) were also the most physically active and more likely to belong to the "Healthy lifestyle" cluster. During adolescence, the circadian rhythm can become delayed (Sadeh et al. 2009), while other health behaviours remain quite healthy. This might partly explain the lack of associations between poor sleep and overweight in our study, where most of the girls' other EBRBs were healthier in the cluster characterized by poor sleep than in the cluster "High screen time, unhealthy lifestyle". Still, girls also reported their sleep to be somewhat poorer in the "High screen time, unhealthy lifestyle" cluster than in the "Healthy lifestyle" cluster. This indicates the need to examine in more detail the interplay between sleep and different kinds of screen-based activities and their associations with the risk of overweight in future studies.

Overweight often stems from several EBRBs, which have been shown to be inter-related behavioural combinations (McAloney et al. 2013). One strength of the present study is its cluster analysis, which identifies subgroups according to their health behaviour, thus making it easier to plan and target health promotion strategies that would most benefit each subgroup (Gubbels et al. 2013). Cluster analysis enables the organization of individuals into meaningful subgroups and the consideration of several EBRBs and their combinations without dichotomization of the variables (McAloney et al. 2013). A further strength of the present study is the inclusion of different sleep-related variables in the cluster analysis of EBRBs and risk for overweight. This is necessary, since short sleep duration and poor sleep quality are related to risk for overweight and other health complaints (Garaulet et al. 2011; Jarrin et al. 2013; Nuutinen et al. 2014). The data consisted of a large, representative sample of Finnish adolescents. The EBRB clusters showed high stability and could, therefore, be considered representative patterns of EBRBs among Finnish adolescents.

The cross-sectional data of the present study do not support causal conclusions. Longitudinal studies could add to our understanding of the stability of these EBRBs and the possible association of the clusters with weight status over the long run. In the present study, all measured variables were based on self-reports. Overweight or obese adolescents underestimate their weight more often than normal-weight adolescents, and girls tend to underestimate their weight more than boys (Sherry et al. 2007). This tendency may have led to the under-classification of overweight and thereby attenuate the results. Since the potential bias concerns the other variables in the present study as well, the results should be considered with caution. The measures have, however, demonstrated appropriate validity and reliability in the previous studies (Griebler et al. 2010; Tynjälä 1999). Some evidence exists that cluster membership varies according to parental socioeconomic status (Leech et al. 2014b). Since we had no precise data on parental socioeconomic status, we adjusted the regression analyses for educational aspiration, which reflects parental education level (Dubow et al. 2009).

Our study shows that behaviours considered healthy co-occur, and vice versa. Over half of the adolescents in this study belonged to the “Healthy lifestyle” cluster. However, only one-third of the adolescents in this cluster attained the recommended levels of PA. Poor sleep, as part of EBRBs, did not increase their risk for overweight, although poor sleep was evident in one group of girls. Rather, increased risk for overweight occurred only among girls belonging to the cluster “High screen time, unhealthy lifestyle”. Identifying the factors (e.g., the social environment) which might promote PA, especially among girls with a high interest in screen-based activities, would prove beneficial.

Acknowledgements This study was funded by the Juho Vainio Foundation in line with Teija Nuutinen’s personal grant. We also acknowledge Samfundet Folkhälsan i svenska Finland r.f. The Health Behaviour in School-aged Children (HBSC) study is an international study carried out in collaboration with the World Health Organization (WHO). We thank the International Coordinator of the 2009/2010 study, Candace Currie, University of Edinburgh, Scotland.

Compliance with ethical standards

Conflict of interest Authors declare that they have no conflict of interest.

Informed consent The adolescents’ participation in the study was voluntary and based on informed consent. In addition, each school’s headmaster independently decided whether to participate in the study.

Ethical approval Ethics approval came from the National Board of Education and the Trade Union of Education.

References

Altenburg TM, Chinapaw MJ, van der Knaap ET, Brug J, Manios Y, Singh AS (2013) Longer sleep–slimmer kids: the ENERGY-project. PLoS ONE 8:59522

Boone-Heinonen J, Gordon-Larsen P, Adair SA (2008) Obesogenic clusters: multidimensional adolescent obesity-related behaviors in the US. Ann Behav Med 36:217–230

Carson V, Tremblay MS, Chaput JP, Chastin SF (2016) Associations between sleep duration, sedentary time, physical activity, and health indicators among Canadian children and youth using compositional analyses. Appl Physiol Nutr Metab 41:S294–S302

Chaput JP, Gray CE, Poitras VJ, Carson V, Gruber R, Olds T et al (2016) Systematic review of the relationships between sleep duration and health indicators in school-aged children and youth. Appl Physiol Nutr Metab 41:S266–S282

Cole TJ, Bellizzi MC, Flegal KM, Dietz WH (2000) Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 320:1240

Craigie AM, Lake AA, Kelly SA, Adamson AJ, Mathers JC (2011) Tracking of obesity-related behaviours from childhood to adulthood: a systematic review. Maturitas 70:266–284

Cuenca-García M, Huybrechts I, Ruiz JR, Ortega FB, Ottevaere C, González-Gross M et al (2013) Clustering of multiple lifestyle behaviors and health-related fitness in European adolescents. J Nutr Educ Behav 45:549–555

Dubow EF, Boxer P, Huesmann LR (2009) Long-term effects of parents’ education on children’s educational and occupational success: mediation by family interactions, child aggression, and teenage aspirations. Merrill-Palmer Q 55:224

Fernández-Alvira JM, De Bourdeaudhuij I, Singh AS, Vik FN, Manios Y, Kovacs E et al (2013) Clustering of energy balance-related behaviors and parental education in European children: the ENERGY-project. Int J Behav Nutr Phys Act 10:5

Garaulet M, Ortega FB, Ruiz JR, Rey-Lopez JP, Beghin L, Manios Y et al (2011) Short sleep duration is associated with increased obesity markers in European adolescents: effect of physical activity and dietary habits. The HELENA study. Int J Obes 35:1308–1317

Griebler R, Molcho M, Samdal O, Incley J, Dür W, Currie C (ed) (2010) Health behaviour in school-aged children: a World Health Organization Cross-National Study. Research protocol for the 2009/2010 survey. Vienna: LBIHPR & Edinburgh: CAHRU

Gubbels JS, van Assema P, Kremers SP (2013) Physical activity, sedentary behavior, and dietary patterns among children. Curr Nutr Rep 2:105–112

Hirshkowitz M, Whiton K, Albert SM, Alessi C, Bruni O, DonCarlos L et al (2015) National sleep foundation's sleep time duration recommendations: methodology and results summary. Sleep Health 1:40–43

Hitze B, Bosy-Westphal A, Bielfeldt F, Settler U, Plachta-Danielzik S, Pfeuffer M et al (2009) Determinants and impact of sleep duration in children and adolescents: data of the Kiel Obesity Prevention Study. Eur J Clin Nutr 63:739–746

Inchley J, Currie D, Young T, Samdal O, Torsheim T, Augustson L et al (ed) (2016) Growing up unequal: gender and socioeconomic differences in young people's health and well-being. Health behaviour in School-aged Children (HBSC) study: international report from the 2013/2014 survey. Copenhagen, WHO Regional Office for Europe, (Health Policy for Children and Adolescents, No. 7)

Jarrin DC, McGrath JJ, Drake CL (2013) Beyond sleep duration: distinct sleep dimensions are associated with obesity in children and adolescents. Int J Obes 37:552–558

Johnson JG, Cohen P, Kasen S, First MB, Brook JS (2004) Association between television viewing and sleep problems during adolescence and early adulthood. Arch Pediatr Adolesc Med 158:562–568

Leech RM, McNaughton SA, Timperio A (2014a) The clustering of diet, physical activity and sedentary behavior in children and adolescents: a review. Int J Behav Nutr Phys Act 11:4

Leech RM, McNaughton SA, Timperio A (2014b) Clustering of children's obesity-related behaviours: associations with sociodemographic indicators. Eur J Clin Nutr 68:623–628

Lobstein T, Baur L, Uauy R (2004) Obesity in children and young people: a crisis in public health. Obes Rev 5(s1):4–85

McAloney K, Graham H, Law C, Platt L (2013) A scoping review of statistical approaches to the analysis of multiple health-related behaviours. Prev Med 56:365–371

Nedeltcheva AV, Kilkus JM, Imperial J, Kasza K, Schoeller DA, Penev PD (2009) Sleep curtailment is accompanied by increased intake of calories from snacks. J Clin Nutr 89:126–133

Nuutinen T, Ray C, Roos E (2013) Do computer use, TV viewing, and the presence of the media in the bedroom predict school-aged children's sleep habits in a longitudinal study? BMC Public Health 13:684

Nuutinen T, Roos E, Ray C, Villberg J, Välimaa R, Rasmussen M et al (2014) Computer use, sleep duration and health symptoms: a cross-sectional study of 15-year olds in three countries. Int J Public Health 59:619–628

Ottevaere C, Huybrechts I, Benser J, De Bourdeaudhuij I, Cuenca-Garcia M, Dallongeville J et al (2011) Clustering patterns of physical activity, sedentary and dietary behavior among European adolescents: the HELENA study. BMC Public Health 11:328

Parsons MJ, Moffitt TE, Gregory AM, Goldman-Mellor S, Nolan PM, Poulton R et al (2015) Social jetlag, obesity and metabolic disorder: investigation in a cohort study. Int J Obes 39:842–848. doi:10.1038/ijo.2014.201

Pereira S, Katzmarzyk PT, Gomes TN, Borges A, Santos D, Souza M et al (2015) Profiling physical activity, diet, screen and sleep habits in Portuguese children. Nutrients 7:4345–4362

Sabbe D, De Bourdeaudhuij I, Legiestand E, Maes L (2008) A cluster-analytical approach towards physical activity and eating habits among 10-year-old children. Health Educ Res 23:753–762

Sadeh A, Dahl RE, Shahar G, Rosenblat-Stein S (2009) Sleep and the transition to adolescence: a longitudinal study. Sleep 12:1602–1609

Sherry B, Jefferds ME, Grummer-Strawn LM (2007) Accuracy of adolescent self-report of height and weight in assessing overweight status: a literature review. Arch Pediatr Adolesc Med 161:1154–1161

Singh AS, Mulder C, Twisk JW, van Mechelen W, Chinapaw MJ (2008) Tracking of childhood overweight into adulthood: a systematic review of the literature. Obes Rev 9:474–488

Strasburger VC, Hogan MJ, Mulligan DA, Ameenuddin N, Christakis DA, Cross C et al (2013) Children, adolescents and the media. Pediatrics 132:958–961

Te Velde SJ, De Bourdeaudhuij I, Thorsdottir I, Rasmussen M, Hagströmer M, Klepp KI et al (2007) Patterns in sedentary and exercise behaviors and associations with overweight in 9–14-year-old boys and girls—a cross-sectional study. BMC Public Health 7:16

Touitou Y (2013) Adolescent sleep misalignment: a chronic jet lag and a matter of public health. J Physiol Paris 107:323–326

Tynjälä J (1999) Sleep habits, perceived sleep quality and tiredness among adolescents. A health behavioural approach. Studies in sport, physical education and health 61, University of Jyväskylä: Jyväskylä University Printing House

Van den Bulck J, Hofman A (2009) The television-to-exercise ratio is a predictor of overweight in adolescents: results from a prospective cohort study with a two year follow up. Prev Med 48:368–371

van der Sluis ME, Lien N, Twisk JW, Steenhuis IH, Bere E, Klepp KI et al (2010) Longitudinal associations of energy balance-related behaviours and cross-sectional associations of clusters and body mass index in Norwegian adolescents. Public Health Nutr 13:1716

Veloso SM, Matos MG, Carvalho M, Diniz JA (2012) Psychosocial factors of different health behaviour patterns in adolescents: association with overweight and weight control behaviours. J Obes. doi:10.1155/2012/852672

Yen CF, Ko CH, Yen JY, Cheng CP (2008) The multidimensional correlates associated with short nocturnal sleep duration and subjective insomnia among Taiwanese adolescents. Sleep 31:1515